

**REMARKS**

The Examiner is thanked for the due consideration given the application and for the withdrawal of the restriction requirement.

Claims 55-79 remain in the application. Claims 80-91 have been canceled by this amendment without prejudice or disclaimer. Claims 1 and 72 have been amended recited "pre-made aerosol catalyst particles", which finds support at page 8, lines 3-4 of the originally filed application (WO 2005/085130). A recitation has been removed from claim 57 without prejudice or disclaimer. The claims have also been amended so as not to utilize "means" language invoking 35 USC §112, sixth paragraph. Other claim amendments improve the language in a non-narrowing fashion.

No new matter is believed to be added to the application by this amendment.

**Claim Objections**

Claim 66 has been objected to as depending upon itself. Claim 66 has been amended to properly depend upon claim 65.

Claim 90-91 have been objected to as being improper multiple dependent claims. Claims 90-91 have been canceled, thus rendering this issue moot.

**Rejection Under 35 USC §112, First Paragraph**

Claims 72 and 75 have been rejected under 35 USC §112 first paragraph as containing subject matter that was not sufficiently described in the specification to convey to one skilled in the art that the inventor had possession of the invention when the application was filed. This rejection is respectfully traversed.

This issue arises from "means-plus-function" recitations used in the claims. However, the claims have been amended so as not to utilized this type of language but to be drawn to a specific "device" such as is set forth, for example, in claim 72. This "device" is further elucidated in claims 73 or 74 as being a pre-reactor or a hot wire generator.

The claims of the invention thus clearly show that the inventor had possession of the invention at the time the application was filed.

This rejection is believed to be overcome, and withdrawal thereof is respectfully requested.

**Rejection Under 35 USC §112, Second Paragraph**

Claims 66, 72, 75, 79 and 81-89 have been rejected under 35 USC §112, second paragraph as being indefinite. This rejection is respectfully traversed.

The Office Action notes that claim 66 depends on itself. Claims 66 has been amended to properly depend upon claim 65.

The Office Action asserts that the "means-plus-function" language is indefinite in light of the original disclosure. However, as noted above, this type of claiming has been removed to thus obviate this issue.

Regarding claim 79, this claim is admittedly couched in functional language. However, functional language does infer structure to one of skill.

A functional limitation is an attempt to define something by what it does, rather than by what it is (e.g., as evidenced by its specific structure or specific ingredients). There is nothing inherently wrong with defining some part of an invention in functional terms. Functional language does not, in and of itself, render a claim improper. *In re Swinehart*, 439 F.2d 210, 169 USPQ 226 (CCPA 1971).

A functional limitation must be evaluated and considered, just like any other limitation of the claim, for what it fairly conveys to a person of ordinary skill in the pertinent art in the context in which it is used. A functional limitation is often used in association with an element, ingredient, or step of a process to define a particular capability or purpose that is served by the recited element, ingredient or step. *Innova/Pure Water Inc. v. Safari Water Filtration Sys. Inc.*, 381 F.3d 1111, 1117-20, 72 USPQ2d 1001, 1006-08 (Fed. Cir. 2004).

Regarding any issues in claims 81 and 86, these claims have been canceled.

The claims are thus clear, definite and have full antecedent basis.

This rejection is believed to be overcome, and withdrawal thereof is respectfully requested.

**Rejections Based On Kamalakaran**

Claims 55-59, 63-67, 70, 72-73, 75-76 and 79 have been rejected under 35 U.S.C. §102(b) as being anticipated by Kamalakaran, *Synthesis of thick and crystalline nanotube arrays by spray pyrolysis*, Applied Physics Letters 2000; 77(21): 3385-3387 in view of Zhang, et al., *Rapid growth of well-aligned carbon nanotube arrays*, Chemical Physics Letters 2002; 362: 285-290 to show a state of fact.

Claims 80-82, 85 and 86-89 have been rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Kamalakaran in view of ZHANG et al.

Claim 68 has been rejected under 35 U.S.C. §103(a) as obvious over Kamalakaran in view of ZHANG et al., and further in view of Maruyama, et al., *Low-temperature synthesis of high-purity single-walled carbon nanotubes from alcohol*, Chemical Physics Letters 2002; 360: 229-334.

Claims 69 and 83-84 are rejected under 35 U.S.C. §103(a) as being unpatentable over Kamalakaran in view of Zhang et al., and further in view of (i) Thostenson, *Advances in the science and technology of carbon nanotubes and their composites*:

a review, Composite Science and Technology 2001; 61: 1899-1912, (ii) Lavin et al. (U.S. Patent 6,426,134) and (iii) Pienkowski et al. (U.S. Patent 6,599,961).

Claims 71 has been rejected under 35 U.S.C. §103(a) as obvious over Kamalakaran in view of ZHANG et al., and further in view of Vivekchand, et al., *Carbon nanotubes by nebulized spray pyrolysis*, Chemical Physics Letters 2004; 386: 313-318.

These rejections are respectfully traversed.

The present invention pertains to producing carbon nanotubes from a gas phase utilizing pre-made aerosol catalyst particles. A reactor that can be used to produce these nanotubes is depicted in Figure 3(a) of the application, which is reproduced below.

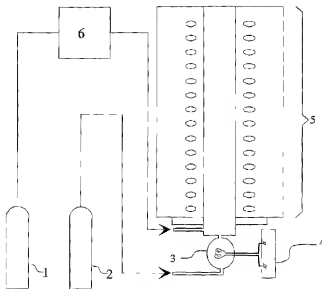


Figure 3(a)

As is set forth in independent claim 55, the nanotubes may be formed by "producing pre-made aerosol catalyst particles

*by physical vapor nucleation of catalyst material or by solution droplet thermal decomposition of catalyst precursor; and reacting said pre-made aerosol catalyst particles and one or more carbon sources in a reactor to produce carbon nanotubes."* See also apparatus claim 72.

Kamalakaran discloses the formation of an aerosol of catalyst material from a solution/suspension and thermally decomposing a carbon source (benzene) to make nanotubes. Kamalakaran also discloses the synthesis of carbon nanotubes by spray pyrolysis of ferrocene/benzene solutions in an Ar atmosphere in a single step process.

Zhang has been referred to in the Office Action as evidencing that ferrocene can be regarded as a source for Fe catalyst particles. However Kamalakaran does not disclose or in any way suggest the separate production of pre-made aerosol catalyst particles and the synthesis of carbon nanotubes in accordance with the present invention.

On the contrary, Kamalakaran discloses the production of catalyst particles simultaneously with the carbon nanotubes synthesis. Therefore, Kamalakaran does not in any way disclose or suggest the formation of catalyst particles beforehand, separately from the carbon nanotube synthesis.

Kamalakaran alone or in combination thus does not anticipate or render *prima facie* obvious independent claims 55

and 72 of the present invention. Claims depending upon claims 55 or 72 are patentable for at least these reasons.

Also, the cancellation of claims 80-91 renders any rejection of these claims moot.

These rejections are believed to be overcome, and withdrawal thereof is respectfully requested.

**Rejections Based On Dillon et al.**

Claims 55-59, 63-68, 70, 72-76 and 79 have been rejected under 35 U.S.C. §102(b/e/a) as being anticipate by WO 03/056078 to Dillon, et al. (U.S. Publication 2004/0265211 AI) in view of Zhang et al.

Claims 80-82 and 85-89 have been rejected under 35 U.S.C. §102(b/e/a) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over WO 03/056078 to Dillon et al. in view of Zhang, et al.

Claim 69 and 83-84 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Dillon et al. in view of Zhang et al., and further in view of (i) Thostenson, (ii) Lavin et al. (U.S. Patent 6,426,134) and (iii) Pienkowski et al.

Claim 71 has been rejected under 35 U.S.C. §103(a) as being unpatentable over Dillon et al. in view of Zhang et al., and further in view of Vivekchand, et al., *Carbon nanotubes by nebulized spray pyrolysis*, Chemical Physics Letters 2004; 386: 313-318.

Dillon et al. disclose the use of gaseous phase carbon precursor material and metal catalyst material for the production of single-walled carbon nanotube material. The metal catalyst material can be a gas phase organo-metallic compound, e.g., ferrocene or cobalt hexacarbonyl, which is introduced into the process chamber at the same time as the carbon precursor material. Alternatively, the metal catalyst material can be provided to the process chamber using a hot wire catalyst filament.

However, in the method of Dillon et al., no actual catalyst particles are used to synthesize nanotubes. Dillon et al. only disclose the use of vaporized catalyst material. Further, Dillon et al. do not disclose the separate production of pre-made catalyst particles and formation/synthesis of carbon nanotubes in accordance with the present invention.

In contrast, in the present invention the metal catalyst precursor material, e.g. ferrocene, is fed into the reaction chamber, where the ferrocene will vaporize simultaneously with the formation of carbon nanotubes. Even in the case where the catalyst material is provided using a hot wire, the catalyst material is provided simultaneously with the formation of carbon nanotubes (and thus can not be separately controlled) not as a separate step in accordance with the present invention.



Dillon et al. alone or in combination thus does not anticipate or render *prima facie* obvious independent claims 55 and 72 of the present invention. Claims depending upon claims 55 or 72 are patentable for at least these reasons.

Also, the cancellation of claims 80-91 renders any rejection of these claims moot.

These rejections are believed to be overcome, and withdrawal thereof is respectfully requested.

**Rejections Based On Simard et al.**

Claims 55-61, 63-68, 70, 72-73, 75-77 and 79 have been rejected under 35 U.S.C. §102(b) as being anticipated by WO 02/076887 to Simard et al.

Claims 80-82 and 85-89 have been rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Simard et al.

Claims 69 and 83-84 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Simard et al., and further in view of (i) Thostenson, (ii) Lavin et al. (U.S. Patent 6,426,134) and (iii) Pienkowski et al.

These rejections are respectfully traversed.

Simard et al. disclose the formation of nanoparticles of metal catalyst via laser ablation and aerosolization and the growth of nanotubes. The features of Simard et al. are not included in the instant independent method claim and the instant independent apparatus claim of the present invention since the

feature of "aerosolization from a powder or suspension" has been deleted from these claims.

Further, the publication of Simard et al. disclose laser ablation of bulk metal catalyst, which is within a hydrocarbon solution, e.g. toluene, in order to form a feedstock containing metal catalyst nanoparticles, which is then atomized and heated to form nanotubes, i.e., the catalyst nanoparticles are produced in the presence of a hydrocarbon solution.

Simard et al. do not in any way teach or suggest the method or the apparatus in accordance with the present invention. A person skilled in the art would not, based on Simard et al., have come up with the present invention, where pre-made aerosol catalyst particles are produced by physical vapor nucleation of catalyst material or by solution droplet thermal decomposition of catalyst precursor, and where separately produced pre-made aerosol catalyst particles and one or more carbon sources are used to produce carbon nanotubes from a gas phase.

Simard et al. alone or in combination thus does not anticipate or render *prima facie* obvious independent claims 55 and 72 of the present invention. Claims depending upon claims 55 or 72 are patentable for at least these reasons.

Also, the cancellation of claims 80-91 renders any rejection of these claims moot.

These rejections are believed to be overcome, and withdrawal thereof is respectfully requested.

**Rejections Based On Sato et al.**

Claims 55-66, 70, 72-73, 75-76 and 79 have been rejected under 35 U.S.C. 102(b/a) as being anticipated by Sato et al., *Growth of diameter-controlled carbon nanotubes using monodisperse nickel nanoparticles obtained with a differential mobility analyzer*, Chemical Physics Letters 2003; 382: 361-366.

Claims 71 and 77-78 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato, et al.

Claims 66-68 have been rejected under 35 U.S.C. §103(a) as obvious Sato et al. in view of Maruyama, et al.

Claim 69 has been rejected under 35 U.S.C. §103(a) as being unpatentable over Sato et al., and further in view of (i) Thostenson, (ii) Lavin et al. (U.S. Patent 6,426,134) and (iii) Pienkowski et al.

These rejections are respectfully traversed.

Sato et al. disclose the generation of nanoparticles by laser ablation, i.e., the production of pre-made catalyst particles. The pre-made catalyst particles are size classified after which they are deposited onto a substrate. Then the substrate with the pre-made catalyst particles, i.e., the nickel particles, is transferred to a CVD chamber, where the growth of carbon nanotubes takes place.

Sato et al. do not disclose a gas phase method for the production of carbon nanotubes using pre-made aerosol catalyst particles and one or more carbon sources during the

formation/synthesis of carbon nanotubes in accordance with instant method claim 55 and instant apparatus claim 72.

In contrast, Sato et al. disclose the production of carbon nanotubes on a substrate, where the catalyst particles are deposited. This is not an aerosol method in accordance with the present invention.

Further, there is no suggestion or teaching in Sato et al. that would lead a person skilled in the art to the present invention, where carbon nanotubes are formed from a gas phase using pre-made aerosol catalyst particles and one or more carbon sources.

Sato et al. alone or in combination thus does not anticipate or render *prima facie* obvious independent claims 55 and 72 of the present invention. Claims depending upon claims 55 or 72 are patentable for at least these reasons.

Also, the cancellation of claims 80-91 renders any rejection of these claims moot.

These rejections are believed to be overcome, and withdrawal thereof is respectfully requested.

#### **Other Art Rejections**

Claims 80-81 and 85 have been rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Bandyopadhyaya, et al., *Stabilization of Individual Carbon Nanotubes in Aqueous Solutions*, Nano Letters 2002; 2(1): 25-28.

Claims 80 and 82-85 have been rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Thostenson.

Claims 80 and 82-85 have been rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Lavin et al.

Claims 80 and 82-85 are rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Pienkowski, et al.

These rejections are respectfully traversed.

The cancellation of claims 80-91 renders these rejections moot, the withdrawal thereof being accordingly respectfully requested.

### **Conclusion**

The Examiner is thanked for considering the Information Disclosure Statements filed December 8, 2006 and September 8, 2006, and for making the references therein of record in the application.

Prior art of record but not utilized is believed to be non-pertinent to the instant claims.

As no issues remain, the issuance of a Notice of Allowability is respectfully solicited.

The Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any

overpayment to Deposit Account No. 25-0120 for any additional  
fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17.

Respectfully submitted,

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